



Construction Technology Laboratories, Inc.

5420 Old Orchard Road
Skokie, Illinois 60077
800.522.2CTL (2285)

March 21, 2001

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PUGET SOUND CLEAN
AIR AGENCY

Mr. Fred Austin
Puget Sound Clean Air Agency
110 Union Street, Suite 500
Seattle, WA 98101-2038

**Results of Dust Fallout Analysis
CTL Project Nos. 153660 & 153668**

Dear Mr. Austin:

Enclosed are two Reports of Laboratory Analysis which contain results of testing for the above referenced projects.

Should you have any questions concerning the enclosed reports, please contact me.

Your samples will be retained until June 2001 when they will be discarded, unless we hear otherwise from you.

We appreciate having this opportunity to be of service to you and anticipate working with you in the future.

Sincerely,

CONSTRUCTION TECHNOLOGY LABORATORIES, INC.

Ronald D. Sturm
Senior Petrographer
rsturm@ctlgroup.com

RDS/hma

Enclosure

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Construction Technology Laboratories, Inc.

MAR 22 2001

AIR AGENCY

5420 Old Orchard Road
Skokie, Illinois 60077
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Client: Puget Sound Clean Air Agency
Project: Dust fallout analysis
Contact: Fred L. Austin
Submitter: Fred L. Austin

CTL Project No.: 153668
CTL Proj. Mgr.: Ronald Sturm
Analyst: Ronald Sturm
Approved: *[Signature]*
Date : 01-Mar-2001

REPORT OF LABORATORY ANALYSIS

One powder samples, provided in a small glass jar, was received on January 10, 2001 from Mr. Fred L. Austin, Air Pollution Engineer for Puget Sound Clean Air Agency, Seattle WA. The sample was provided with a chain-of-custody form that was signed upon receipt. Reportedly, the powder sample represent particulate dust (fallout) settled on the exterior of an automobile at Olympic Tug & Barge, 910 SW Spokane St., Seattle. The following sample identification, descriptions, and location were provided by Mr. Austin:

<u>P.S. Clean Air Sample ID</u>	<u>Sample Description</u>
Nov 36879 # 200500905-1 (Dec 26, 2000)	Fallout dust sample from one car – Automobile License No. LPN 89335-Y

Laboratory analysis of the sample was requested by Mr. Austin to identify the constituents of the dust fallout. Analyses consisted of optical, polarized-light and reflected light microscopy and x-ray diffraction analysis (XRD) and of each sample. Prior to analysis, the sample was split into three portions, each portion given a unique CTL sample number. One split was not analyzed. The samples were split and identified as follows:

<u>P.S. Clean Air Sample</u>	<u>CTL Sample ID</u>	<u>Test Designated</u>
# 200500905-1	328201-1	Microscopy
	328201-2	XRD
	328201-3	Not analyzed

FINDINGS

Microscopy

The following lists provide the identified constituents, in order of relative abundance, within the referenced dust fallout tape samples, as determined by optical, microscopical examination:

CTL ID **P. S. Clean Air ID No.**
328201-1 **# 200500905-1**

Predominant Constituent¹

- Unhydrated, partially hydrated, and hydrated masses of portland cement clinker (Figs. 1, 2, and 3); mainly small, gray to beige grains and masses (about 30 to 200 μm across). Many of the masses exhibit relics of hydraulic crystalline compounds commonly associated with portland cement clinker, including tricalcium and dicalcium silicate (*alite* and *belite*) crystals bound in a matrix of tetracalcium aluminoferrite (*ferrite*), tricalcium aluminate, and other related compounds (Fig. 3). Such compound assemblage and morphology is typical of hydraulic portland cement clinker. Many of the masses exhibit evidence of partial hydration (reaction with water), resulting in formation of secondary hydration products that have subsequently carbonated. The latter form carbonated hydration rims.

Minor Constituents

- Light gray to buff colored, friable clumps and masses (some up to 150 μm across) of fine-grained carbonate material (suspected to be hydrated portland cement clinker that has subsequently carbonated).
- Miscellaneous mineral grains (10 to 150 μm) including calcite, quartz, feldspar, amphiboles, mica, opaque minerals, and other rocks and minerals (Fig. 1);
- Traces (less than 1% each) of paper and plant fibers, rust flakes, glass-like fragments, and other (unidentified) crystalline and non-crystalline particles.
- A few masses exhibit evidence of partial hydration (reaction with water), resulting in formation of secondary hydration products that have not carbonated, including needle-like crystals of ettringite ($3\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot3\text{CaSO}_4\cdot32\text{H}_2\text{O}$) and suspected occurrences of hydrated alkali sulfates, calcium hydroxides, and other related compounds.

X-ray Diffraction Analysis

Findings of the x-ray-diffraction analysis are provided in the attached data sheets. These analyses are generally consistent with the findings of the optical microscopy. Each dust sample is comprised predominantly of crystalline compounds normally associated with portland cement clinker, including alite (C_3S), belite (C_2S), and ferrite (C_4AF). Calcite (CaCO_3) was also identified and likely is attributed to carbonated formed of cement hydration products.

¹ Predominant constituent comprises an estimated 80 to 85% of sample.

ADDITIONAL COMMENTS

The primary constituents of the particulate dust fallout sample is comprised of portland cement clinker and carbonated forms of hydrated portland cement clinker. The remaining constituents of each sample include particles deemed to be fairly common constituents of dust in an urban or industrial location.

Detailed examination of the portland cement clinker particles and relic remains of hydrated cement clinker revealed most are highly irregular and porous masses comprised of mostly unbroken crystals of alite and belite (tricalcium and dicalcium silicates) bound in an interstitial matrix. Many of the masses exhibit an agglomeritic appearance. Angular, fractured clinker particles (consistent with ground portland cement) are scarce. Furthermore, no detectable amounts of gypsum or plaster (mineral additives found in most ground and processed portland cements) were identified in the dusts. Based on these observations, the majority of the particulate dust represented in the submitted samples is judged to be consistent with fugitive dust from cement manufacturing operations.

METHODS OF TEST

Microscopy

The referenced particulate dust sample was initially examined using a stereomicroscope during which particle size and morphology was noted and preliminary identification of coarse particles and fibers was performed. Representative portions of the powder were placed on glass microscope slides and immersed in liquids of known refractive index ($n = 1.55$ and 1.70). Each **immersion mount** was topped with a glass coverslip and examined using a transmitted, polarized-light microscope at magnification up to $400\times$. Also, select individual particles were removed from the dust, placed on glass slides in liquids of known refractive indices, and examined in a similar manner. Particle identification was based on particle morphology and optical properties.

An additional immersion mount was made from the powder sample using epoxy resin mixed with hardener ($n = 1.55$) and allowed to set without a coverslip. After the epoxy hardened, the immersed sample was finely ground and polished. The resulting **polished immersion mount** was etched with a "Nital" solution and examined using a reflected-light microscope to further study the dust and confirm the presence of portland cement clinker.

X-Ray Diffraction Analysis

A split portion of the referenced powder sample was processed to a fine powder, passing No. 200 mesh sieve. The fine powder was then mounted on an aluminum sample holder and subjected to X-ray diffraction analysis as a packed powder. Refer to the attached report for additional details of the analysis.

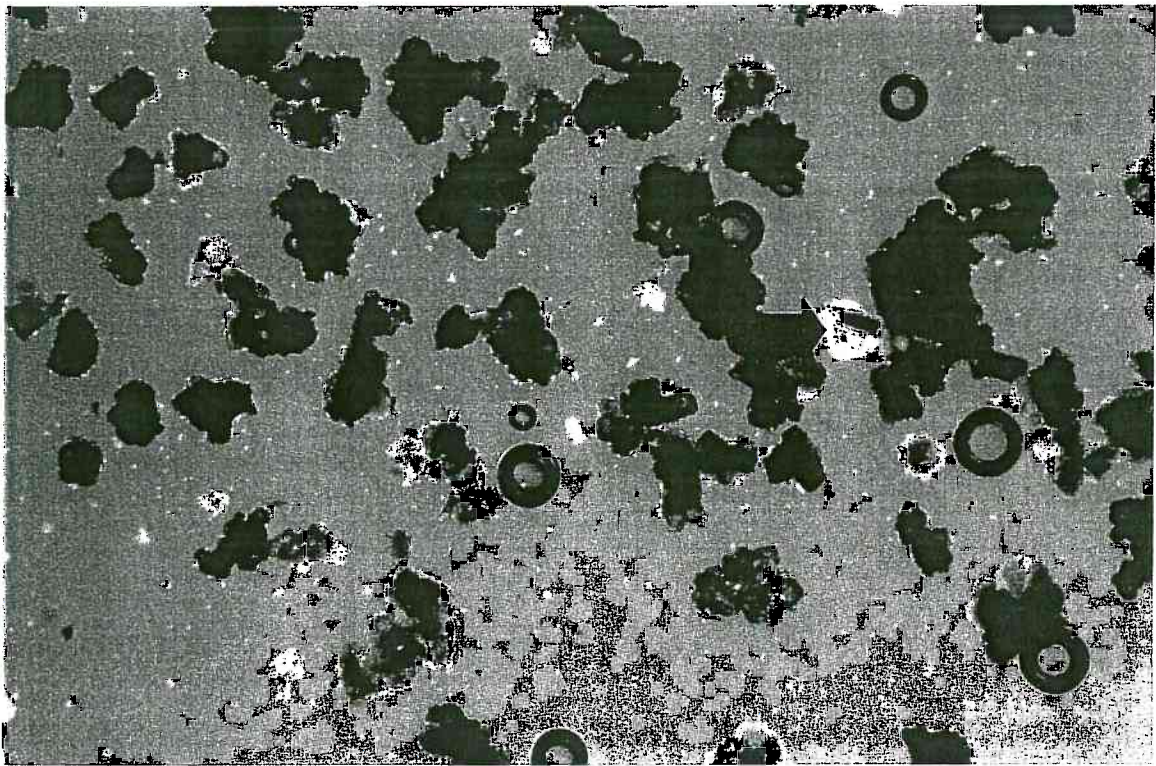


Fig. 1 Photomicrograph of a portion of the immersion mount for Sample # 200500905-1 shows the powder is comprised mainly of agglomerated masses of portland cement clinker (dark shadowed particles) with lesser occurrences of natural mineral grains (marked with arrow), and other particulate. Transmitted, partially-crossed polarized light.

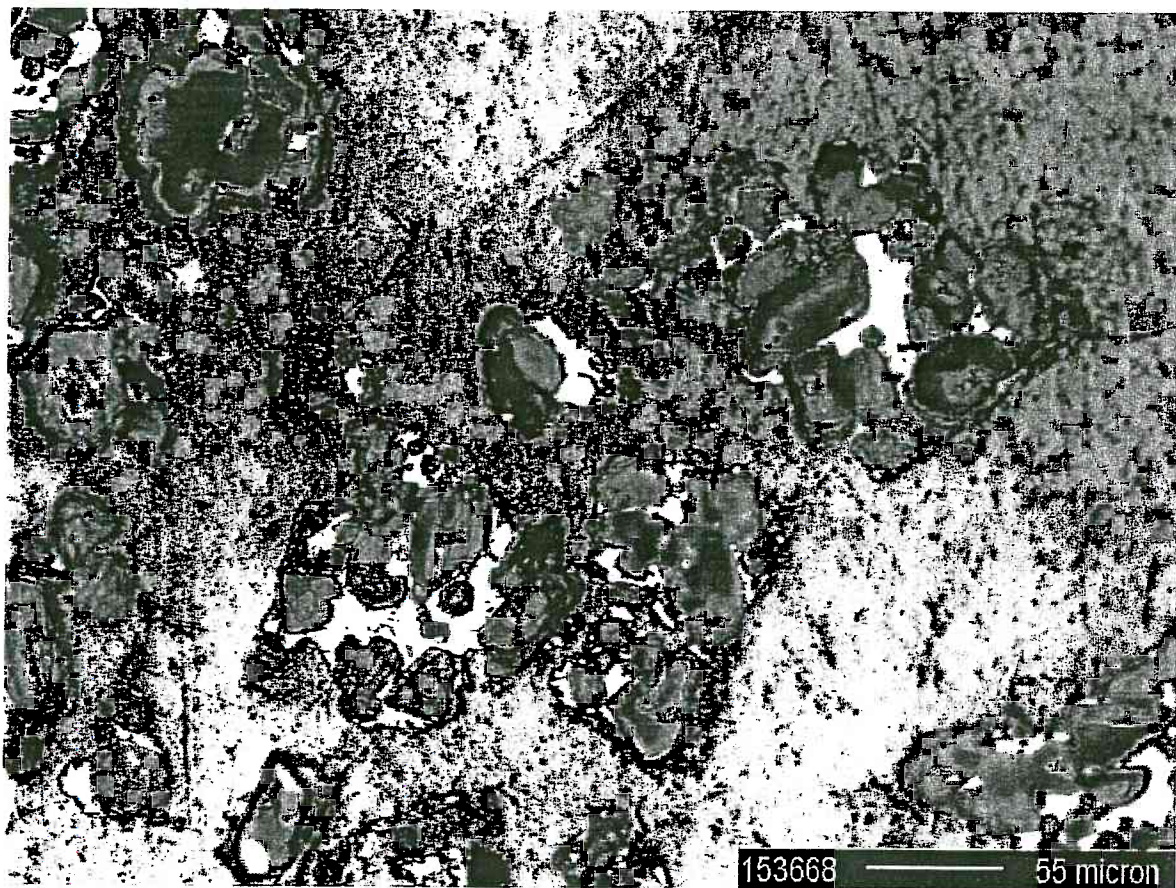


Fig. 2 Photomicrograph of a polished and etched immersion mount for Sample # 200500905-1 shows the general morphology of the particulate and crystalline compounds consistent with portland cement clinker. Reflected light.

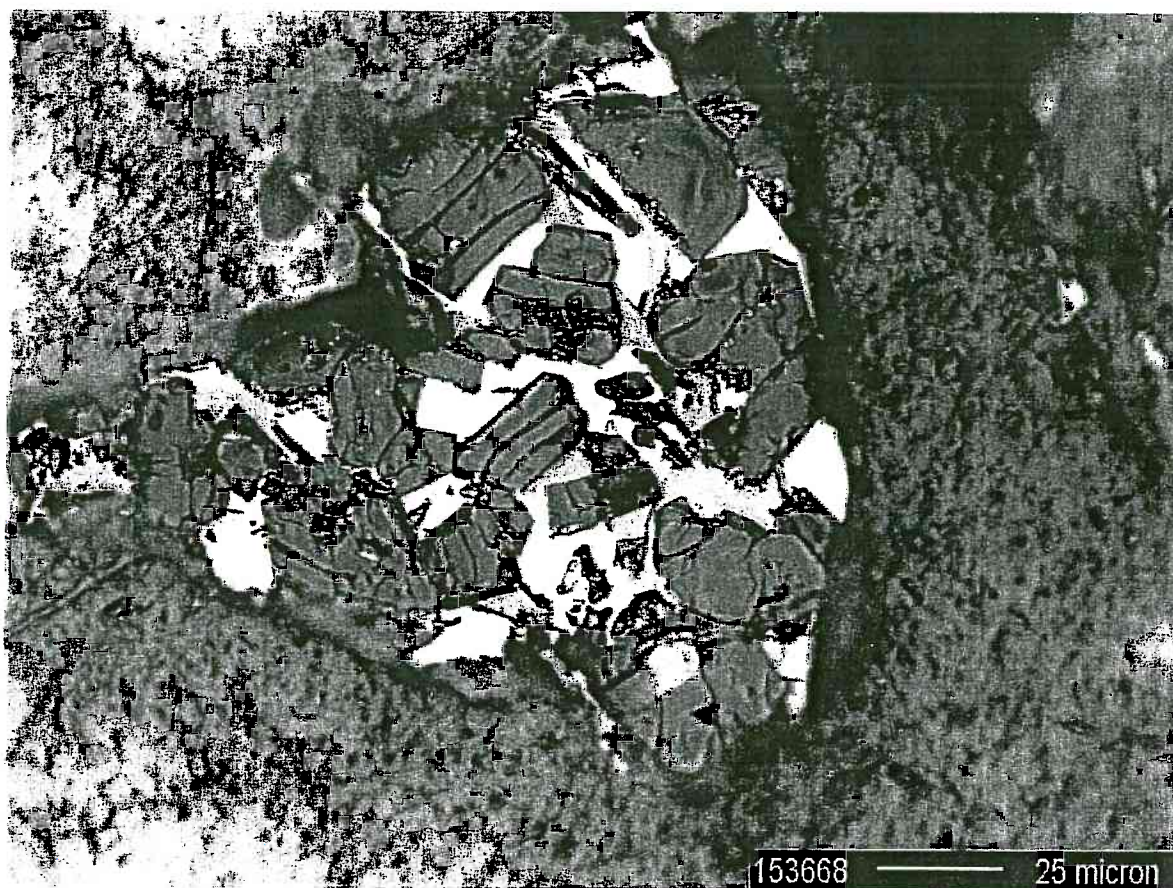


Fig. 3 Additional photomicrograph of a polished and etched cross section of a representative particle in Sample # 200500905-1, at higher magnification. The particle clearly exhibits crystalline phases consistent with portland cement clinker. Reflected light.



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Client:	Puget Sound Clean Air Agency	CTL Project No.:	153668
Project:	X-ray diffraction analysis	CTL Proj. Mgr.:	Ronald Sturm
Contact:	Mr. Fred Austin	Analyzed by:	Luis Graf
Submitter:	Ron Sturm	Approved:	Fulvio Tang <i>FT</i>
		Date:	01/24/01

X-RAY DIFFRACTION (XRD) ANALYSIS

A sample identified as Dust 2000500905-1 was received from Ron Sturm for X-ray diffraction analysis. The sample was first processed to a fine powder passing No. 200 mesh sieve. The fine powder was then mounted on an aluminum sample holder and analyzed as a packed powder.

The analysis was done using a Phillips 1720 X-ray generator (Cu-K α radiation) equipped with a θ -compensating slit, graphic monochromator, gas proportional counter detector, and a Phillips PW 3710 MPD control unit connected to a PC.

Scanning of the sample was carried out in the 2θ -angle range from 5 to 65 degrees for 1 hour and at a step size of 0.02 degrees for a total of 3000 steps.

Identification of crystalline phases was facilitated with the help of Phillips' X'Pert Software.

XRD analysis showed the presence of the following phases in the proportions indicated by the relative peak intensities:

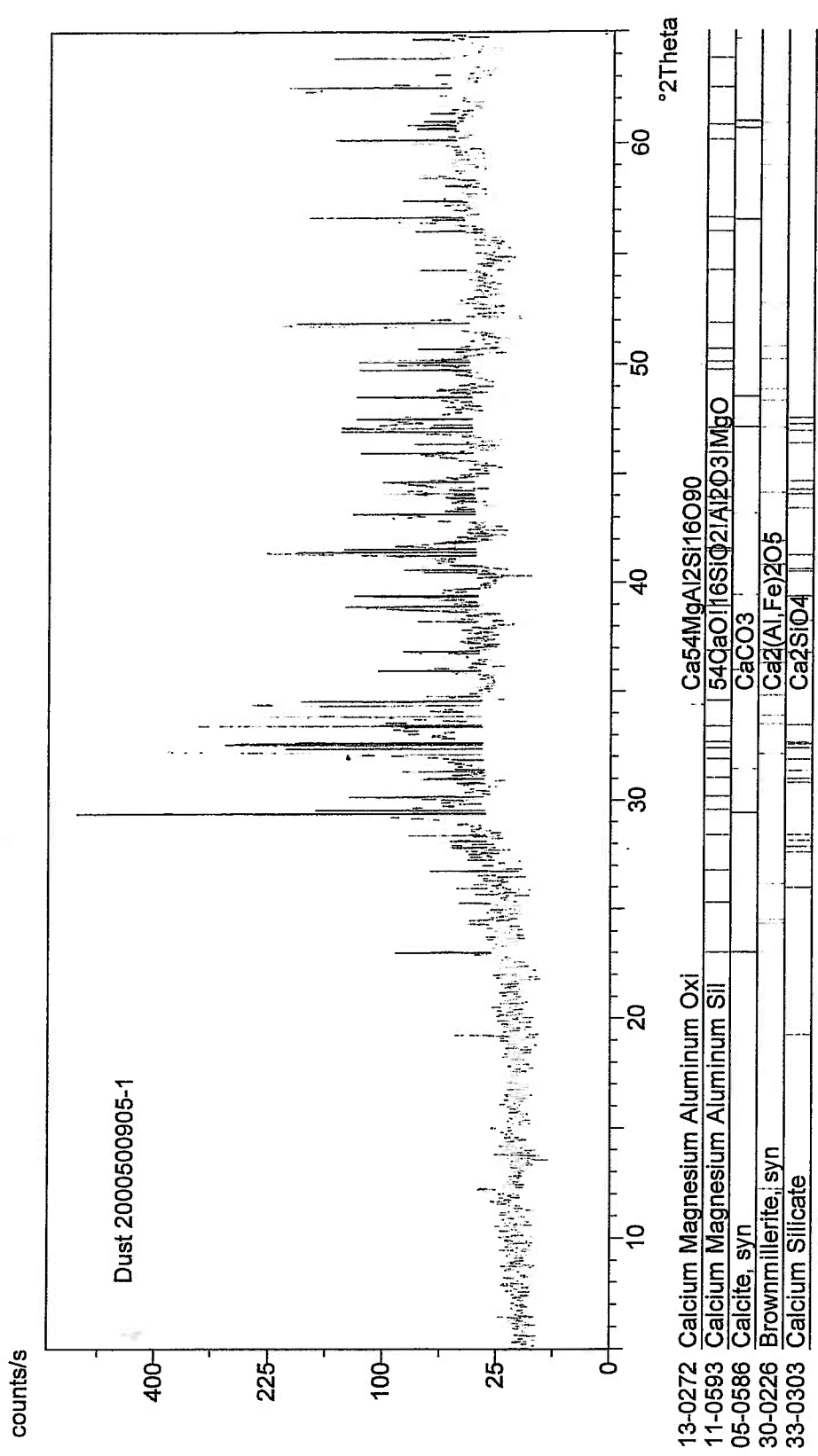
- Calcium Magnesium Aluminum Silicon Oxide, C₃S (alite)
- Calcium Silicate, C₂S (belite)
- Brownmillerite, C₄AF
- Calcite, CaCO₃

See attached graphs of the XRD measured and reference patterns.

Alite, belite, and C₄AF are major components of portland cement clinker. Calcite was probably formed as a result of carbonation of calcium hydroxide, which is one of the principal hydration products of alite or belite.

Enclosed:

1. XRD pattern of dust sample 2000500905-1 and identified reference patterns.



Phillips Analytical